the high temperature of the continents exert a considerable influence. Then occasionally a continuous return of polar air may be established along the west coast of the continents and leading direct into the trade winds.

These results can not fail to exert a considerable influence upon the methods of weather forecasting. All meteorological events of the Temperate Zone, great and small, derive from the described great atmospheric circulation, as we know it from the motions of the polar front. If we succeed in watching it effectively, it should be possible to give the short-range forecasts a hitherto unattained accuracy. And it should be possible to complete them by long-range forecasts giving the general character of the weather perhaps for weeks ahead. And these two kinds of forecasts could be extended to all regions of the Temperate Zone, to oceans as well as to continents. The required survey of the polar front is merely a question of organization.

551.524 (048)

PROPAGATION OF COLD AIR ON THE SURFACE OF THE EARTH.[1]

By F. M. EXNER.

[Reprinted from *Science Abstracts*, Sect. A, Sept. 30, 1920, §1137.]

The general problem for solution is: Given a mass of dense air of known form and state of motion, covering a small region of the earth's surface, and bounded above and around by less dense air also in known state of motion, to determine the subsequent movement and changes of form of the dense air. The problem is solved for some particular cases in two dimensions, by the hydrodynamical methods applicable to waves at the surface between two fluids of unequal density, but the results sought are mainly qualitative. The dense air is taken initially in the form of a ridge of rectangular cross-section and infinite length. If both fluids are originally at rest, and friction and the earth's rotation are neglected, then the ridge breaks up into two of equal breadth and half the height of the original, traveling in opposite directions perpendicular to their length with a velocity proportional to the square root of the difference of absolute temperature between the cold and warm air. As the ridges move apart the warm air flows in and covers the region of the earth's surface between them. Introducing friction, the ridges separate as before, but decrease in height as they advance, the space between them remaining covered with cold air. In this case, too, the rear of each advancing ridge is higher than the front. On a rotating earth without friction the cold ridge, supposed streaming in the direction of its length, breaks up as before, but the ridge traveling to the left of the direction of streaming (Northern Hemisphere) increases in height, while the other decreases. The velocity of propagation is now greater than before, and the front of each ridge higher than the rear. If the warm air above is streaming at right angles to the ridges, it has the effect of checking the advance of one of them, and may, if strong enough, reverse its motion and make it slowly follow the other, which has its velocity of propagation increased. Other cases are obtained as combinations of these. A comparison is made with observations on the spreading of cold waves over Europe and North America. The author finds in this work an explanation of the phenomena exhibited on these occasions, and in particular of the observed fact that when cold air breaks through from the polar regions it first seeks to spread W. or SW., then S., SE., E., and often finally NE.—*M. A. G.*

[1] Akad. Wiss., Vienna, vol. 127, 2a, 1918, pp. 795–847.

551.515 (048)

THE ENERGY OF CYCLONES.

In several issues of *Nature* (London) late in 1920 there has appeared a running discussion of the source of the energy of cyclones. There is presented such a concise nontechnical summary of the present ideas of British meteorologists on this intricate subject that extensive quotations are reprinted here. The discussion was started by adverse criticism of Margules's theory by R. M. Deeley. In an obituary of Dr. Max Margules, published in *Nature* (London) October 28, 1920, pp. 286–287,[1] E. Gold gives the following short summary of Dr. Margules's discussion of the energy of storms:

Margules contributed to the Year Book of the Meterological Institute of Vienna for 1903 a comprehensive discussion of the energy of storms. He showed that the atmospheric phenomena associated with storms would arise if two masses of air of different temperatures were in juxtaposition. The situation would be unstable, and in passing from this unstable situation to a stable one the potential energy would be reduced, part of it being converted into the kinetic energy of the ensuing "storm." This paper contains the germ of the theory of squalls, of the development of cyclones, of polar fronts, and so forth. It concludes computations of the horizontal velocities which would result from various distributions of pressure and temperature, and shows that actual distrib tions would lead to velocities of 50 miles an hour. Margules summed up his conclusions in the sentence: "So far as I can see, the source of storms is to be sought only in the potential energy of position."

Mr. Deeley, in a letter to *Nature* (Nov. 11 issue, p. 345), criticises many of Margules' points, and concludes with the following sentence:

The facts seem to point to the stratosphere as being the main source of energy of storms and trade winds.

To this Lieut. Col. Gold replies (ibid.):

Dr. Margules wrote his paper mainly in connection with phenomena of the line-squall type, but he realized that it might have wider applications, and later investigations do indicate that discontinuity of temperature is the prime factor in the "birth" of cyclones. If one had an atmosphere with uniform pressure at sea level, but with masses of warm and cold air, then at 9 kilometer pressure would necessarily be low in the mass of cold air, and a cyclonic circulation would ensue; but the enrgy of motion would be derived from the potential energy of the initial state.

Differences of temperature originate in the lower atmosphere. The stratosphere may be able to draw upon a source of energy of which we are ignorant; it can not of itself provide the energy of storms.

In the next issue of *Nature* (Nov. 18, pp. 375–376), W. H. Dines presents the following further discussion:

It does not seem to me as though any really satisfactory theory has yet been put forward to explain the genesis and maintenance of cyclones; I fully agree with Mr. Deeley (Nov. 11, p. 345) that they are not due to contiguous masses of air at different temperatures but, on the other hand, I do not see how they can originate in an inert and stable region like the stratosphere.

Were storms produced by contrasts of temperature—or in other words, by the so-called polar front—surely they would be most violent where the contrast was most marked. The stormiest parts of the world are the great belt of the southern ocean from 40° to 60° S. latitude, and that part of the Atlantic which lies northwest of Scotland, and neither of these regions shows any exceptionally steep gradient of temperature.

Observations in the upper air have shown a remarkable uniformity in the mean temperature (mean with regard to height) from 0 to 20 kilometers in every place where they have been obtained, and it follows as a corollary that there is a very uniform pressure at 20 kilometers height over the globe, for the pressure at 20 kilometers is almost independent of the surface pressure. Observations over Europe, the only part of the world where they are numerous enough for the purpose, have also shown a most extraordinarily close correlation between the temperature and pressure of the air in the upper part of the troposphere,

[1] Abstract published in *Mo. Weather Rev.*, Oct., 1920, 48:601.